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INFLUENCE OF THE USE OF THE TELEPHONE UPON THE HEARING POWER.[1]

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THE assertion made by the writer several years since, that the habitual use of the telephone would be prejudicial to the hearing in many cases where the hearing was already impaired, was based upon the well-known facts of the process of accommodation in the middle ear for the transmission of tones of low intensity, of the susceptibility of the percipient apparatus to shock from sharp sounds of high intensity under the conditions of that process, and upon the results of measurements of the vibrations of telephone discs made for the purpose of determining approximatively the loss of power between the transmitting and receiving telephones. These experiments, the results of which were embodied in a paper read before the British Society of Telegraph Engineers in London in 1878, consisted in connecting two hand telephones, similar to those at present in general use, by means of flexible wires and recording the excursions of the discs of both the transmitting and receiving telephones by means of fine platinum wires tracing upon smoked glass. The excursion of the transmitting telephone disc without the magnet was first recorded, the average for all the readings for a constant tone of 448 vibrations measured under the microscope, with micrometer eye-piece being 0.2625 millimetre. The deflection of the centre of the disc under magnetic attraction was 0.061 millimetre, the result of this being a decrease of the

[1] Read before the Am. Otological Society, Washington, September, 1888. Reprinted from the Archives of Otology, Vol. xvii., No. 3, 1888.

excursion in response to the same tone to 0.180 millimetre, a difference in the length of the excursion of 0.0725 millimetre, or about 27.65 per cent.

The movement of the receiving disc, as recorded on the smoked glass, was so slight that a large number of tracings was made, the average of which was, however, always within 0.02 millimetre, and controlling tests were made by means of a micrometer screw, reading to one-thousandth of a millimetre, connected with a delicate galvanometer, the results gained confirming the previous measurements of the transmitting disc and determining the average excursion of the receiving disc at 0.0135 millimetre, a loss in motion of *92.9* per cent. between the two telephone discs. This loss of intensity is in a measure compensated for by the effort made in the ear itself to accommodate itself to the transmission of tones of low intensity, which effort, in its prime degree, can be maintained, as shown by experiment, for little more than fifteen seconds, at the end of which time the symptoms of fatigue (in a decrement of the hearing) begin to appear. Under this condition the ear is peculiarly susceptible also to the shock of such sharp metallic sounds as are constantly occuring in the practical use of the telephone. Estimating the amount of power in sound transmitted to the ear from the receiving telephone as but 7.1 per cent. of that which actuates the transmitting disc, the compensation required of the ear would seem to be considerable, particularly when it must be sustained for a long period, but when the attempt to estimate the percentage of the loss of the difference between consonant sounds of nearly the same logographic value, and consonant sounds, moreover, the pneumatic value of which results in a damping of the transmitting disc—by driving it further toward the magnet,—it is infinitely greater.

Soon after the experiments above mentioned were made, the microphone transmitter, using a battery current, came into general use, and it seemed advisable to review the subject in the light of experiments more delicate and more accurate than the crude measurements made ten years ago.

For the results which follow I am indebted to Prof. W.

W. Jaques, of the American Bell Telephone Company, who, connecting a Blake transmitter with a hand telephone by a wire circuit, and comparing the values between sound aërially and telephonically transmitted, as measured by the distance from the ear, came to the conclusion that the speech given out by the receiver on a short line is approximately one ten-thousandth of the loudness of that going into the transmitter.[1]

By a still later series of experiments the extent of the accommodative power of the ear, and correspondingly the demand made upon it, is still further illustrated. Connection was made between the New York and Boston offices of the Telephone Company and the laboratory of the Massachusetts Institute of Technology in Boston, by means of a complete metallic (copper) circuit. The distance over this wire from the New York to the Boston office was 260 miles, and from the Boston office to the laboratory of the Institute, two miles. A Hunnings transmitter was placed at each of these stations, and at the Institute of Technology; an electro-dynamometer was also included in the circuit.

On speaking into the transmitter at the Institute, the electro-dynamometer gave a deflection of 22. millé amperes, speaking into the transmitter at the Boston office the current was 0.48 millé amperes, and speaking at New York it was 0.02 millé amperes; the current was thus eleven hundred times as strong from the transmitter at the Institute as from that in New York; and yet the conversation was

[1] "Taking D as the aërial and d as the telephonic transmission, the squares of the distances D and d should give an approximate measure of the loudness of speech going into the transmitter (T) and coming out of the receiver (R): $\frac{D^2}{D^2} = E$ = the efficiency of the system or the relation of the sound emitted to that extent.

"The mean of the first series of experiments was

"$D = 240$ in., $d = 2.5$ in. $\Big\}$ $E = .00011$

"The mean of a second series was

"$D = 360''$, $d = 3.2''$ $\Big\}$ $E = .00009$

"With two hand telephones, one as a transmitter, the other as a receiver:

"$D = 360$ in., $d = 0.8$ in. $\Big\}$ $E = .000005$

"Under a microscope, the movement of one electrode of a transmitter relative to the other was .00025 in., and the movement of the receiver disc was .000005 in. or less."—Extract from letter dated Boston, Nov. 14, 1887.

distinctly audible in both cases, and the ear did not recognize any enormous difference in the intensity of the sound.[1]

These facts so amply confirm the previous statements that they should be well borne in mind, especially since the telephone is an instrument the use of which will, in the future, increase rather than diminish, and since it is, moreover, not likely, with our present knowledge, to be essentially improved, the principal gains in clearness and distinctness of sound transmitted having to come from improvements in the means of communication rather than from changes made in the receiving instrument itself. All attempts at damping the high metallic overtones and improving the qualitative distinction between the consonant sounds as heard, by changing the structure of the receiving telephone, having resulted in a corresponding loss of that intensity, of which, as has been shown, there is so little to spare.

[1] Extract from letter dated Boston, June 20, 1888.